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LIFE HISTORY AND LABORATORY REARING OF *OEDANCALA DORSALIS* (SAY) (HETEROPTERA: LYGAEIDAE), WITH DESCRIPTIONS OF IMMATURE STAGES[1]

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Abstract.—The life history of the seed bug *Oedancala dorsalis* (Say) was investigated in southern Illinois from June 1994–November 1995, and the immature stages were described. The bug also was reared from egg to adult under controlled laboratory conditions. This apparently bivoltine species fed and reproduced on *Carex* spp. Adults overwintered and became active in April. Eggs were found from mid-May to early September in the spikes of *Carex crinita*. Seasonal occurrences of adults and nymphs are discussed. Adults were last observed in mid-October. This species was reared on *C. crinita* in the laboratory at 26 ± 0.5°C under a 16L:8D photoperiod. The incubation period averaged 13.32 days. The five nymphal stadia averaged 6.34, 5.28, 4.52, 4.02, and 5.52 days, respectively.

Key Words: Seed bug, Lygaeidae, southern Illinois, life history, laboratory rearing, immature stages, descriptions, *Carex*

The family Lygaeidae contains approximately 4050 species worldwide (Slater and O'Donnell 1995). Next to the family Miridae, it is the second largest family of Heteroptera in America north of Mexico, where it is represented by approximately 320 species (Ashlock and Slater 1988). Lygaeids are commonly called seed bugs, referring to their habit of feeding on dry, mature seeds (Sweet 1960).

In the United States and Canada, the lygaeid subfamily Pachygronthinae contains the three genera *Oedancala* Amyot and Serville, *Pachygrontha* Germar, and *Phlegyas* Stål (Ashlock and Slater 1988). Only five species of *Oedancala* occur within this geographic area (Ashlock and Slater 1988, Baranowski and Slater 1989). Of these, *O. dorsalis* Say is the most widespread, ranging from Ontario, Quebec, and Maine south to Florida, and west to South Dakota, Colorado, and Texas, and is the only species of the genus that has been reported from Illinois (Ashlock and Slater 1988, Baranowski and Slater 1989).

Oedancala dorsalis has been little studied. It has been swept from herbage in wet meadows, pastures, and waste places (Blatchley 1926), and reported to feed on *Carex*, *Cyperus* (Van Duzee 1888, Slater 1951), *Ceanothus*, and marsh grasses (Slater 1951). Van Duzee (1888) found adults from May to September "about" Buffalo, New York. Uhler (1887) stated it rarely was found later than early summer in eastern North America and felt it was "single brooded." It overwinters under leaves and around the tussocks at the edges of swamps (Torre-Bueno 1925); small colonies have been found beneath logs along the borders of woodlands in late October (Blatchley 1926).

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This lygaeid has been reared in the laboratory under unspecified conditions and the egg and nymphal instars, except the second, have been described (Slater 1951).

In this paper, we present information on the field life history in southern Illinois and laboratory rearing of *O. dorsalis* and describe the immature stages.

Materials and Methods

Field life history.—During summer 1994, several adults were observed feeding and copulating on the spikes of *Carex crinita* Lamarck in the La Rue-Pine Hills Research Natural Area, Union County, IL. The site is located along the south side of Forest Road 345, approximately 1.25 miles (2.01 km) east of State Highway 3. The plants (approximately 80 individuals) were growing at the bases of red maple (*Acer rubrum* L.) located at the edge of La Rue Swamp. The population of *O. dorsalis*, although small, seemed sufficiently large to permit a life history investigation of the bug. Therefore, a study was conducted from June 1994 to November 1995. Counts of all nymphs and adults observed in the field, and notes on their activity, were taken weekly from early April to early November, before the bugs emerged from and after they entered overwintering sites, respectively. Specimens were collected by hand picking. Nymphs large enough to be identified to instar, and adults, were released. Others were preserved in 70% ethanol and taken to the laboratory for closer examination. Also, five *C. crinita* staminate spikes were taken to the laboratory weekly and inspected for eggs.

Species of *Carex*, other than *C. crinita*, that served as host plants were noted from Pine Hills; Oakwood Bottoms, Jackson Co.; and Lake on the Campus, Southern Illinois University at Carbondale, Jackson Co. Bugs were recorded as feeding if their rostra were inserted in seeds or if many individuals were on the same plant.

Potential overwintering sites (e.g., leaf litter, under bark of fallen trees) were examined periodically during November–March.

Laboratory rearing.—Ten adults were collected on 17 May and on 24 May 1995, brought to the laboratory, and placed in two oviposition cages (5 males, 5 females/cage). Each cage consisted of a 1-quart (approximately 0.95-liter) Mason jar with a disc of moistened filter paper on the bottom. A pistillate spike of *C. crinita* (collected outside the study site) served as food and was inserted in a vial (8.5 cm length, 2.3 cm diam at base) containing distilled water stoppered with cotton; the vial was placed upright in the bottom of the cage. The cage was closed with a disc of paper toweling and wire screening secured with the band of the two-piece Mason jar lid. A strip of paper toweling (approximately 3 × 20 cm), which provided additional area for excrement absorption, was placed inside the jar with one end over the lip and held in place by the band.

The cages were examined daily for eggs, which were removed and placed on moistened filter paper in the bottom of a petri dish (approximately 9 cm diam., 2 cm depth) and covered with the lid. A thin layer of petroleum jelly was applied to the inside of the rim to help prevent the first instars from escaping. Additionally, the lids were secured with two strips of masking tape to insure a tight fit.

Nymphs (including the firsts) were kept in petri dishes prepared similarly to those for eggs (e.g., a ring of petroleum jelly); a section of a pistillate spike served as food. The nymphs were grouped by molting dates to accurately determine the stadia.

Food and filter paper in the cages and jars were changed, and distilled water was added, approximately every 2–3 days; the exception to this was that once oviposition began, spikes in the cages were replaced daily because they were destroyed during examination for eggs.

To obtain information on reproductive behavior and fecundity (fertility was determined in laboratory rearing), field-collected

fifth instars were brought to the laboratory and placed in Mason jars prepared similarly to oviposition cages. As they reached adults, they were segregated by sex in two additional Mason jars. At the end of a minimum of two weeks, six pairs were placed in petri dishes (one male, one female/dish) prepared similarly to those used for nymphs but without the ring of petroleum jelly. Behavioral observations were made for periods of 1–2 hours.

All specimens were kept in incubators maintained at 26±0.5°C and a 16L:8D photoperiod (approximately 2800 lux).

Descriptions of immature stages.—The description of each stage is based on ten individuals. Eggs and first through fifth instars were selected from field collected and laboratory reared individuals; all had been preserved in 70% ethanol. Only those that had not swelled in the alcohol were used in the descriptions. Drawings were made with the aid of a camera lucida. Measurements, in mm, were made with an ocular micrometer.

Statistics.—Averages are expressed as $\bar{x} \pm SE$; standard errors of less than 0.005 are listed as 0.00. Total developmental periods for males and females were compared with Student's t-test; level of significance was 0.05.

Results and Discussion

Field life history.—*Oedancala dorsalis* overwintered as adults that became active in late April (Figs. 1, 2), began feeding and copulating on spikes of maturing *Carex crinita*, and reproduced shortly thereafter; it remained on the host into October. Adults and nymphs also fed on *C. blanda* Dewey, *C. cephalophora* Muhlenberg, *C. comosa* F. Boott, *C. conjuncta* F. Boott, *C. crus-corvi* Shuttleworth, *C. frankii* Kunth, *C. granularis* Muhlenberg, *C. squarrosa* L., *C. tribuloides* Wahlenberg, *C. vulpinoidea* Michaux, and *C. vulpinoidea* var. *ambigua* F. Boott (= *C. annectens* Bicknell) (Table 1). One adult and two nymphs were observed on *C. lurida* Wahlenberg and *C. lupulina* Muhlenberg, respectively, but were not observed feeding.

Eggs were found on *C. crinita* from mid-May to early September. They usually were laid singly, but, sometimes, they were deposited side by side in clusters of 2–5. Generally, they were inserted between the scales of staminate spikes; occasionally, they were found in pistillate spikes inserted between the scale and perigynium. Similar ovipositional behavior has been observed in other species of *Oedancala* (Baranowski and Slater 1982, 1989).

The first instars were found from early June to early September (Figs. 1, 2). They were observed most commonly near the bases of the staminate spikes with their yellowish orange abdomens protruding from between the perigynia. Second instars were found from mid-June to early September, third instars from mid-June to early October, fourth instars from late June to mid-October, and fifth instars from early July to early October. Second instars through adults were observed most commonly clinging to the pistillate spikes, feeding on seeds. If disturbed, nymphs often would fall to the ground and remain motionless; adults sometimes would fly a short distance to another plant or to the ground.

The mating position was end-to-end. No precopulatory behavior was observed in the field. Copulating adults were noted from late May to late June and from mid-July to early August. Other than mating, little interaction between individuals was observed.

Although adults clearly overwinter, no individuals were located in the field between November and March. Overwintered adults were most abundant from late May to early July and died off soon thereafter. New adults appeared in late July as evidenced by the appearance of callow adults (N = 6) and rise in number of adults following the first peak of fifth instars. Based on the peaks of abundance of the adults, eggs, and the first-fifth instars (Figs. 1, 2), and the two periods of copulation (see

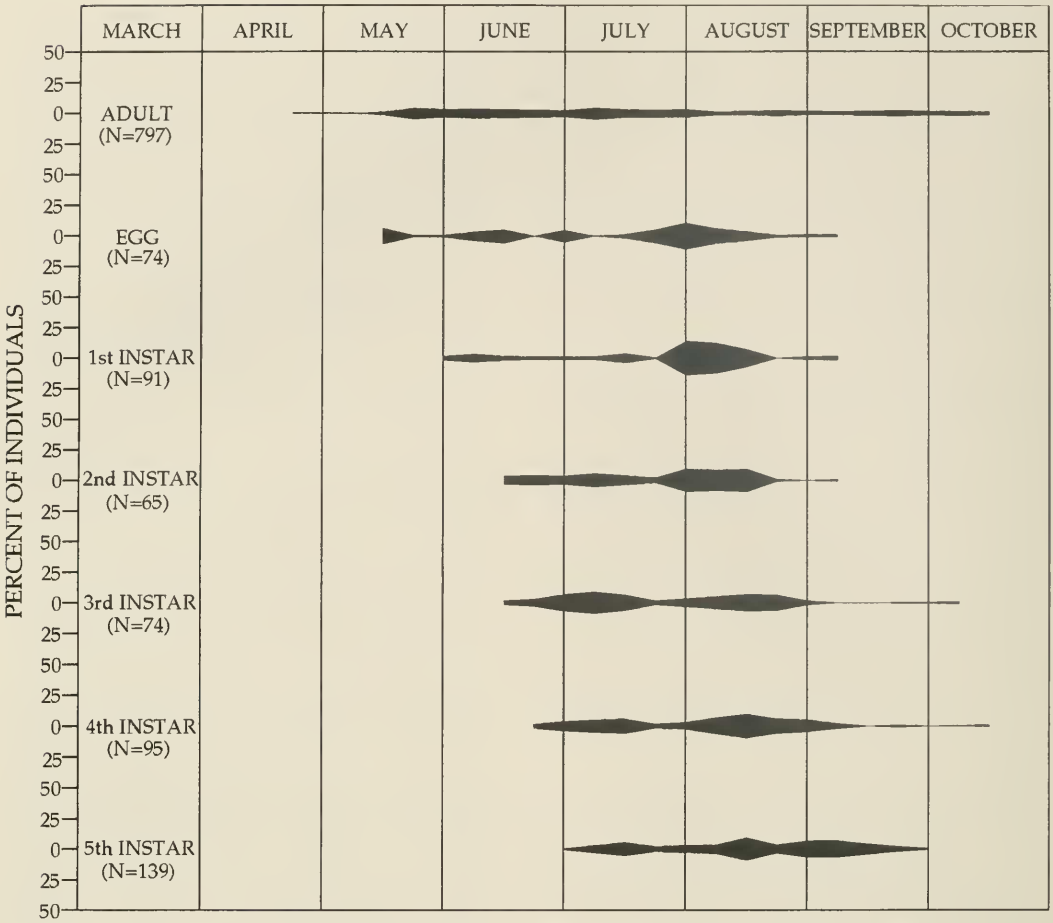


Fig. 1. Field cycle of *Oedancala dorsalis*. Percent in each sample of total individuals of same stage collected during 1995 season in Union Co., IL.

above), *O. dorsalis* apparently was bivoltine in southern Illinois.

Laboratory rearing.—Adults fed and copulated on the pistillate spikes of *C. crinita*. Of the 697 eggs laid during this study, 90.2% were inserted in the pistillate spikes between the scales and perigynia and 1.1% in the filter paper, and 7.8% were laid on the cotton and 0.9% on the sides of the jar. Most were laid singly (68.1%) or side by side in clusters of 2 or 3 (28.0%), less commonly in clusters of 4–7 (3.9%).

The incubation period averaged 13.32 days (Table 2). Eggs were pale green when laid, turning yellowish in 2–3 days. Pink eyespots were visible in 5 to 6 days. At this time, the anterior half of the egg began to redden; the posterior half remained yellowish. The minute egg burster and the paired dorsal sclerites of the abdomen were visible in 8 days.

The first instar emerged through a slit in the cephalic end of the egg. The ground color was yellowish just after emergence; the sclerotized areas were pink but darkened to brown within 3–5 hours.

The first, second, third, fourth, and fifth stadia averaged 6.34, 5.28, 4.52, 4.02, and 5.52 days, respectively. The total developmental period was 39.00 days (Table 2). There was no significant difference between total developmental period for males (37.34

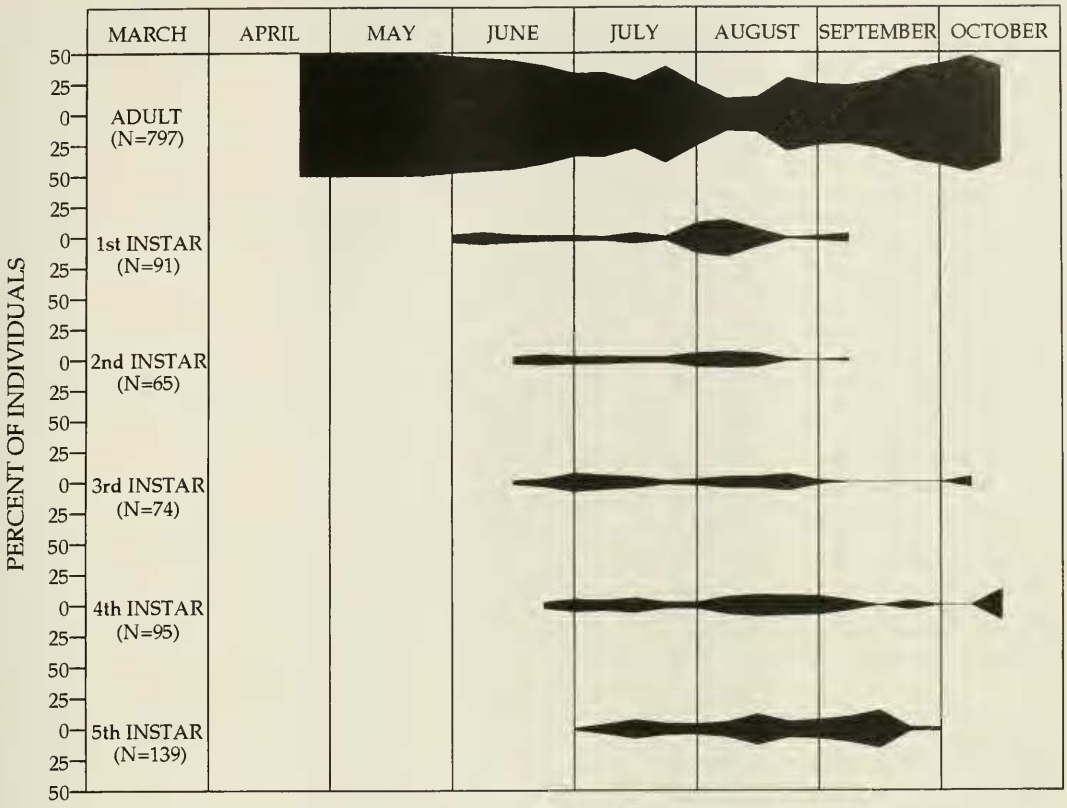


Fig. 2. Field cycle of *Oedancala dorsalis*. Percent of individuals of each stage per sample during 1995 season in Union Co., IL.

± 0.35 days, N = 125) and females (36.89 ± 0.32 days, N = 122) (Student's t-test = −0.9429, df = 245, p = .3467).

Mortality during the nymphal stadia resulted from incomplete ecdysis and unnatural causes (e. g., drowning in water condensation inside the dishes).

Precopulatory behavior was observed between three pairs of males and females and lasted 5–10 minutes. In two of the encounters, the first contact was head-to-head with both individuals touching antennae in a slow, irregular, up-and-down motion. Subsequently, the male moved around to the side of the female while antennating her, continued until he was behind her, and then mounted her from the side and extended his genitalia downward until engaged. In one of the two pairings, the male tapped the female with his legs during mounting. After 5 minutes, while still copulating and remaining attached, the male dismounted and rotated to about an 80° angle; shortly thereafter, the pair assumed a 180° end-to-end position. During copulation, the female moved about the petri dish, pulling the male. Copulation lasted approximately an hour. In the third encounter, the female initiated copulation. She antennated the male and crawled on and off his back repeatedly. The pair began copulating shortly thereafter. The male cleaned its rostrum and antennae during copulation. This pair remained in *copula* for approximately 25 minutes.

The six pairs of adults reproduced in the laboratory, with the females averaging 53.33 ± 13.37 eggs (range, 10–108).

The F_1 adults produced a second generation. In addition, fifth instars collected in

Table 1. Southern Illinois food plants of *Oedancala dorsalis*.

Host Taxon	Stages Collected[a]	Collection Site[b]
Cyperaceae		
Carex blanda Dewey	A	PH
C. cephalophora Muhlenberg	N, A	PH
C. comosa F. Boott	N, A	LC, PH
C. conjuncta F. Boott	A	OB
C. crinita Lamarck	N, A	LC, PH
C. crus-corvi Shuttleworth	A	PH
C. frankii Kunth	N, A	OB, PH
C. granularis Muhlenberg	A	PH
C. squarrosa L.	N, A	OB
C. tribuloides Wahlenberg	N, A	OB
C. vulpinoidea Michaux	N, A	OB, PH
C. vulpinoidea Michaux var. *ambigua* F. Boott (= *C. annectens* Bicknell)	N, A	OB, PH

[a] N = nymph; A = adult.

[b] LC = Lake on the Campus, Southern Illinois University; OB = Oakwood Bottoms; PH = La Rue-Pine Hills/Otter Pond Research Natural Area.

Table 2. Duration (in days) of each immature stage of *Oedancala dorsalis* under controlled laboratory conditions.

Stage	Number Completing Stadium	Range	$\bar{x} \pm$ SE	Cumulative mean age
Egg[a]	621	10–16	13.32 ± .03	13.32
Nymph				
1st instar	533	3–10	6.34 ± .04	19.66
2nd instar	427	2–12	5.28 ± .09	24.94
3rd instar	307	1–15	4.52 ± .12	29.46
4th instar	263	2–11	4.02 ± .07	33.48
5th instar	247	2–8	5.52 ± .04	39.00

[a] 697 eggs were laid.

the field in late July and brought to the laboratory reached adults and subsequently reproduced. Both of these observations support our statement that *O. dorsalis* is bivoltine in southern Illinois.

Descriptions of immature stages.—*Egg* (Fig. 3A–B): Length, 1.41 ± 0.01; width, 0.34 ± 0.01. Eggs usually laid singly, sometimes in small clusters of 2–7; each elongate and whitish to pale green at oviposition, turning yellowish red during maturation. Chorion with longitudinal ridges; 3–7 micropylar processes in ring pattern at cephalic end.

Nymphal instars: The first instar is described in detail, but only major changes from previous instars are described for subsequent instars. Comparative statements (e.g., more punctate) refer to previous instars. The length is measured from tip of tylus to tip of abdomen and the width, across the widest part of the body. Additional measurements are given in Table 3.

First instar (Fig. 4): Length, 1.59 ± 0.02; width, 0.66 ± 0.01. Body generally yellowish orange in live specimens, paler in preserved ones. Sclerotized areas of head, thorax, abdomen, and legs dark brown. Head, thorax, and abdomen lightly setose; legs and antennae moderately setose. Body elongate, slightly pyriform, greatest width across abdominal segments 2–3.

Head narrowed in front, lateral margins tapering before antennae. Tylus exceeding juga, apex broad. Compound eyes red; pale line extending from inner margin of each eye posteromedially, meeting at midline of vertex, then extending to posterior margin of head. Antennae four segmented; segments 1 to 3 yellowish, segment 4 brown, segments white at incisures; segment 1 extending beyond apex of tylus; segment 4 acute apically; ratio of antennal segment lengths approximately 9:10:10:18. Rostrum four segmented, brown, extending onto abdominal segment 1.

Pro- and mesonota mostly sclerotized; sclerotized areas concolorous with head, in form of paired plates, plates separated medially. Pronotal plates subquadrate. Mesonotal plates subrectangular, posterior margins generally straight, laterally bending posteriorly, plates approximately 0.4× length of pronotal plates at midline. Metanotum more membranous; paired sclerites present, each subelliptical, approximately 0.7× length of mesonotal plates at midline. Thoracic pleura sclerotized, concolorous with corresponding notal plates; spiracles present on posterior margins of pro- and

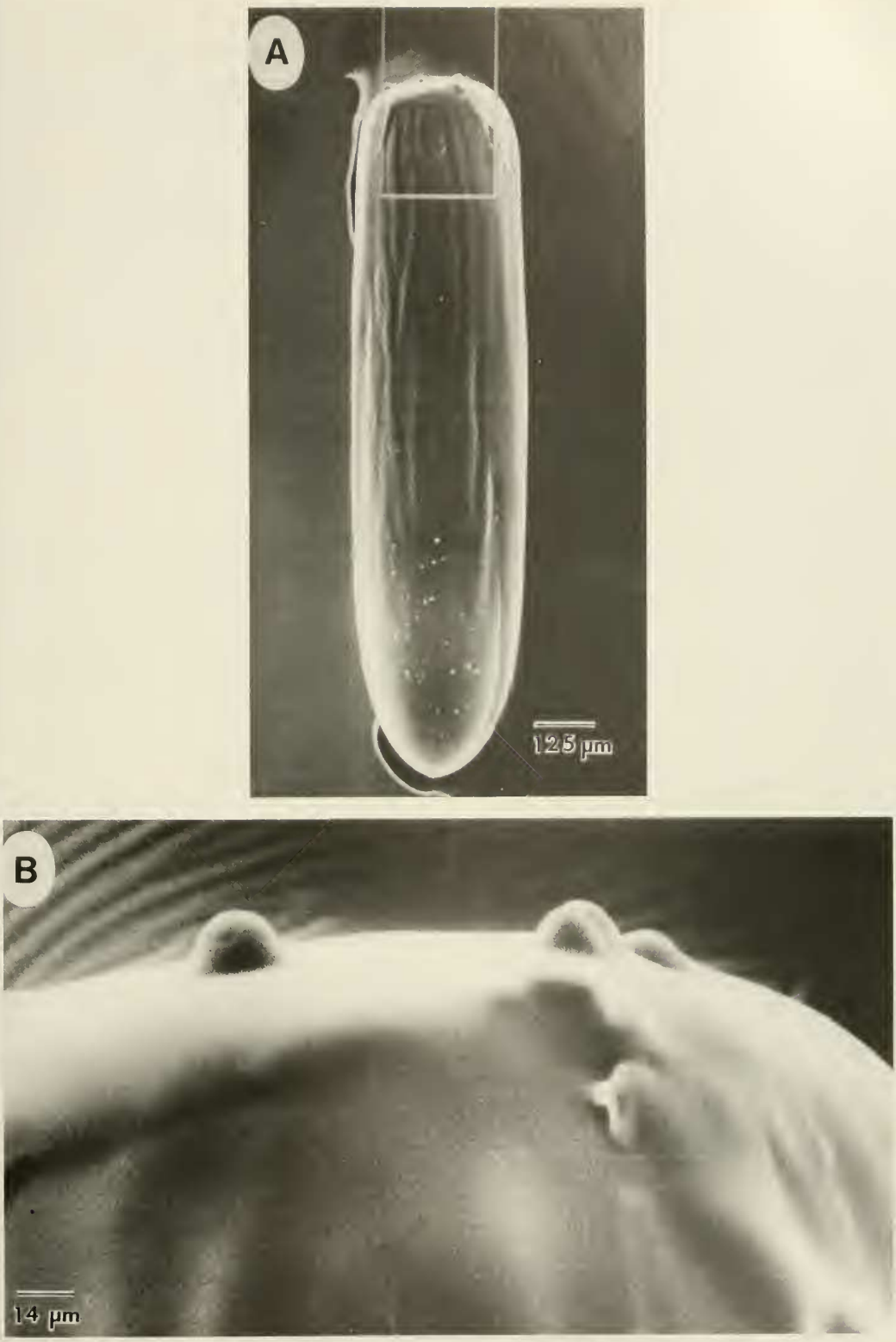


Fig. 3. Scanning electron micrographs of egg of *Oedancala dorsalis*. A, Egg. B, Micropylar region.

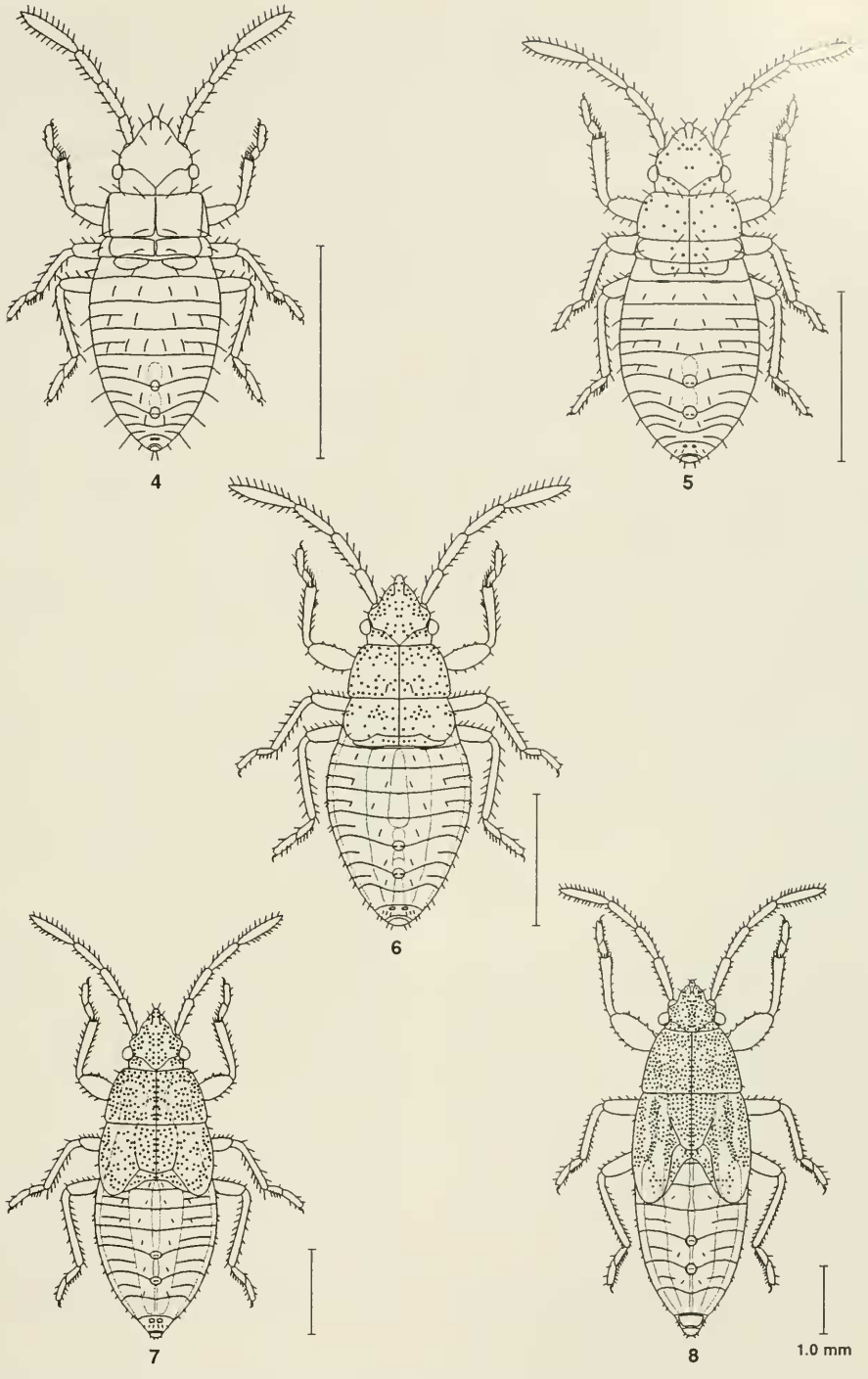
Table 3. Measurements (mm)[a] of *Oedancala dorsalis* instars.[b]

	Nymph				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Body length[c]	1.59 ± 0.02	2.02 ± 0.03	2.66 ± 0.05	3.81 ± 0.06	5.26 ± 0.08
Antennal segs.					
1st	0.18 ± 0.00	0.22 ± 0.00	0.32 ± 0.01	0.49 ± 0.01	0.75 ± 0.01
2nd	0.20 ± 0.00	0.26 ± 0.00	0.34 ± 0.00	0.45 ± 0.01	0.61 ± 0.01
3rd	0.20 ± 0.00	0.25 ± 0.00	0.34 ± 0.00	0.44 ± 0.00	0.59 ± 0.01
4th	0.37 ± 0.00	0.41 ± 0.00	0.50 ± 0.01	0.61 ± 0.01	0.74 ± 0.01
Head width at eyes	0.43 ± 0.00	0.57 ± 0.01	0.73 ± 0.01	0.93 ± 0.01	1.14 ± 0.01
Synthlipsis	0.32 ± 0.00	0.41 ± 0.01	0.52 ± 0.01	0.64 ± 0.01	0.75 ± 0.01
Head length[c]	0.30 ± 0.01	0.41 ± 0.01	0.50 ± 0.01	0.71 ± 0.02	0.86 ± 0.02
Beak segments					
1st	0.18 ± 0.00	0.25 ± 0.00	0.31 ± 0.00	0.40 ± 0.01	0.47 ± 0.01
2nd	0.23 ± 0.00	0.29 ± 0.00	0.35 ± 0.00	0.44 ± 0.01	0.52 ± 0.01
3rd	0.17 ± 0.00	0.23 ± 0.00	0.29 ± 0.00	0.39 ± 0.01	0.45 ± 0.01
4th	0.24 ± 0.00	0.28 ± 0.00	0.34 ± 0.00	0.40 ± 0.00	0.46 ± 0.00
Notal lengths[c]					
Pronotum	0.20 ± 0.01	0.29 ± 0.01	0.43 ± 0.01	0.69 ± 0.02	1.02 ± 0.01
Mesonotum	0.10 ± 0.00	0.17 ± 0.01	0.31 ± 0.01	0.59 ± 0.02	0.93 ± 0.02
Metanotum	0.10 ± 0.00	0.11 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.11 ± 0.00
Notal widths					
Pronotum	0.49 ± 0.01	0.69 ± 0.01	0.96 ± 0.02	1.36 ± 0.03	1.81 ± 0.02
Mesonotum	0.53 ± 0.01	0.74 ± 0.02	1.04 ± 0.02	1.51 ± 0.03	2.16 ± 0.02
Metanotum	0.60 ± 0.01	0.80 ± 0.02	0.92 ± 0.02	1.00 ± 0.04	1.27 ± 0.06
Leg lengths					
Profemur	0.30 ± 0.01	0.40 ± 0.00	0.56 ± 0.01	0.85 ± 0.01	1.29 ± 0.01
Protibia	0.31 ± 0.01	0.41 ± 0.01	0.57 ± 0.01	0.80 ± 0.01	1.12 ± 0.01
Protarsus	0.22 ± 0.00	0.25 ± 0.00	0.33 ± 0.01	0.43 ± 0.01	0.57 ± 0.01
Mesofemur	0.29 ± 0.01	0.38 ± 0.01	0.50 ± 0.01	0.72 ± 0.01	1.01 ± 0.01
Mesotibia	0.30 ± 0.00	0.39 ± 0.00	0.54 ± 0.01	0.75 ± 0.01	1.01 ± 0.01
Mesotarsus	0.21 ± 0.00	0.25 ± 0.00	0.32 ± 0.01	0.42 ± 0.01	0.55 ± 0.01
Metafemur	0.34 ± 0.01	0.44 ± 0.01	0.61 ± 0.02	0.89 ± 0.01	1.27 ± 0.01
Metatibia	0.39 ± 0.01	0.51 ± 0.01	0.68 ± 0.01	0.97 ± 0.01	1.35 ± 0.02
Metatarsus	0.25 ± 0.01	0.29 ± 0.01	0.39 ± 0.01	0.49 ± 0.01	0.69 ± 0.01
Abd. width	0.66 ± 0.01	0.90 ± 0.02	1.22 ± 0.04	1.64 ± 0.03	1.95 ± 0.05

[a] $\bar{x}$ ± SE; values of <0.005 listed as 0.00.
[b] Based on 10 individuals of each instar.
[c] Measured at midline.

mesopleura. Thoracic sterna membranous, concolorous with membranous areas of nota. Coxae, trochanters, and femora generally brownish; tibiae brownish, yellowish apically; tarsi yellowish, last segment brownish in apical half; profemora slightly thickened, ventral margin usually with two small spines in distal half; tarsi two segmented.

Abdomen with paired scent glands medially on intersegmental lines between segments 4 and 5, and 5 and 6; each pair surrounded by circular, sclerotized plate; scent glands visible as median orange masses. Tergum 8 with pair of small, suboval sclerites medially; tergum 9 with posterior two thirds sclerotized; terga 1–6 each with sparse, transverse row of setae, 2–8 each



Figs. 4–8. Nymphal stages of *Oedancala dorsalis*. 4, First instar. 5, Second instar. 6, Third instar. 7, Fourth instar. 8, Fifth instar.

with single lateral seta, those of 5–7 longest; terga 2–7 each with faint pseudointersegmental line visible. Spiracles ventrolaterally on segments 2–8. Sterna 5–9 each with single medial plate, plates of variable shape; sterna 5 and 6 each with pair of small sublateral sclerites; sternum 7 with sublateral sclerite each side on posterior margin; setae generally more numerous than those on corresponding terga.

Second instar (Fig. 5): Length, 2.02 ± 0.03; width, 0.90 ± 0.02. Sclerotized areas of head and thorax sparsely and irregularly punctate.

Ratio of antennal segment lengths approximately 11:13:13:20.

Thorax with notal plates larger, fused medially, forming single plates; pale, median fusion line evident from near anterior margin of pronotum to posterior margin of metanotum. Pronotal plate covering pronotum. Mesonotal plate nearly covering mesonotum, subrectangular, posterior margin concave, approximately 0.5× length of pronotum at midline. Metanotum with plates fused; resulting plate subrectangular, covering approximately half of metanotum, approximately 0.3× length of mesonotum at midline. Paired, small, narrow, transverse sclerites on intersegmental line between metanotum and abdominal segment 1. Profemora thicker, ventral margin dentate in distal half with sparse row of teeth, distal two most prominent.

Abdomen, dorsally, sometimes with three poorly defined, reddish, longitudinal stripes, one medial and two lateral; segments 5–7 with lateral setae equal in length to those on remaining segments. Tergum 9 almost completely sclerotized.

Otherwise, similar to first instar.

Third instar (Fig. 6): Length, 2.66 ± 0.05; width, 1.22 ± 0.04. Sclerotized area of head and thorax more punctate.

Ratio of antennal segment lengths approximately 16:17:17:25.

Mesonotal plate larger, covering mesonotum, posterior margin concave medially, approximately 0.8× length of pronotum at midline; wing pads visible, small, not extending beyond posterior margin of metanotal plate. Metanotal plate larger, covering more than two thirds of metanotum, posterior margin straight, approximately 0.3× length of mesonotal plate at midline. Intersegmental sclerites between metanotum and abdominal segment 1 sometimes hidden by metanotum. Thoracic spiracles obscured by sclerotized pleura. Profemora thicker, teeth on ventral margin more prominent.

Abdomen with three stripes better defined; lateral setae often paired. Sterna 3–9 with medial sclerites, those on sterna 3–4 paired; intersegmental lines of sterna 1–5 occasionally with paired, transverse, linear, medial sclerites.

Otherwise, similar to second instar.

Fourth instar (Fig. 7): Length, 3.81 ± 0.06; width, 1.64 ± 0.03. Punctures more numerous. Body width usually greatest at abdominal segments 2–3.

Head with sclerotized areas generally yellowish to yellowish brown; dorsum with posterior margin dark brown to black. Pair of red ocelli sometimes visible, posterior and mesad to eyes. Ratio of antennal segment lengths approximately 10:9:9:12. Rostrum extending onto metasternum.

Thorax with sclerotized areas generally yellowish to brown; pleura with continuous, longitudinal, dark brown to black stripe, obscure to clearly defined. Pronotum usually with pair of longitudinal dark-brown to black stripes. Mesonotum with pair of stripes, concolorous and continuous with those of pronotum; mesonotum 0.9× length of pronotum at midline; wing pads longer, extending to abdominal tergum 2. Metanotal plate larger, completely covering metanotum, posterior margin arcuate; metanotum approximately 0.2× length of mesonotum at midline; wing pads evident laterally, extending to abdominal tergum 2, almost entirely covered by mesonotal wing pads. Meso- and metafemora and sometimes profemora more yellowish; profemora thicker, ventral margin dentate with three

prominent subequal teeth distally, separated by smaller teeth.

Abdomen, dorsally, with three, reddish, longitudinal stripes now clearly defined; ventrally, with pair of diffuse, sublateral, reddish, longitudinal stripes. Tergum 8 with sclerites larger.

Otherwise, similar to third instar.

Fifth instar (Fig. 8). Length, 5.26 ± 0.08; width, 2.16 ± 0.02. Punctures more numerous. Body width usually greatest across mesothorax.

Head with sclerotized areas yellowish. Ocelli clearly visible. Antennal segment 1 brown on inner margin, remainder of segment yellowish; segment 2 yellowish; segment 3 yellow proximally, reddish brown to brown distally; segment 4 brownish; ratio of antennal segment lengths 5:4:4:5. Rostrum yellowish, extending onto posterior margin of mesosternum.

Thorax with sclerotized areas yellowish to yellowish brown; ventrally with pair of brown markings on meso- and metathoraces. Pronotum with stripes reduced, mesonotum with stripes still well defined; mesonotum 0.9× length of pronotum at midline; metanotum 0.1× length of mesonotum at midline; meso- and metanotal wing pads longer, extending onto abdominal tergum 3 or 4. Legs yellowish, ventral margin of profemora dark brown; profemora greatly swollen, ventral margin dentate with four prominent subequal teeth, separated by smaller teeth; tarsi apically, subacute dorsally.

Abdomen, ventrally, with two well-defined, longitudinal, sublateral red stripes; longitudinal red stripe present medially, varying from diffuse to well defined. Tergum 8 with paired sclerites fused to form plate almost entirely covering dorsal surface.

Otherwise, similar to fourth instar.

Diagnosis.—The five nymphal instars, in addition to size, can be separated readily by the relative lengths of the pro- and mesonota; sclerotization of the metanotum; relative lengths of the lateral abdominal setae; presence or absence of dorsal abdominal stripes; presence or absence, and degree of development, of wing pads; and presence or absence, and number and density, of punctures.

There is a progressive increase in the length of the mesonotum relative to the pronotum through all instars. The first instar can be separated from later instars by the lack of a single sclerotized plate on the metanotum, the relatively longer lengths of the lateral setae on abdominal terga 5–7, lack of punctures, and lack of dorsal abdominal stripes. The second instar can be distinguished from later instars by the lack of distinct mesonotal wing pads; wing pad development becomes apparent in the third instar with progressive development in the subsequent instars. The third-fifth instars can be distinguished from each other by the length of the mesonotal wing pads, which reach the metanotum in the third instar, abdominal tergum 2 in the fourth, and abdominal tergum 3 or 4 in the fifth. Finally, there is a progressive increase in the number and density of punctures in the second-fifth instars.

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